**Group Problem**

A friend of yours who is studying film has asked that you help him recreate the opening scene from the movie *Raiders of the Lost Ark*. In this scene, a huge spherical boulder rolls toward Indiana Jones (played by Harrison Ford) almost crushing him, just as he narrowly escapes out the mouth of a cave. The boulder appears to start from rest about 5 meters above the ground and roll down a ramp that is about 15 meters long. The boulder does not roll exactly on its bottom edge because it is rolling between two rails. Assume that the rails contact the boulder at a point about 1/4 of the way between the bottom of the boulder and the center of the boulder. Your friend needs to know how fast the boulder is moving just as it is about to hit Indiana Jones and how long Indiana has to avoid the boulder once it starts to roll.

Context-Rich Problems: Solutions Outline

FOCUS the PROBLEM
Draw a picture of the situation including ALL the information given in the problem.
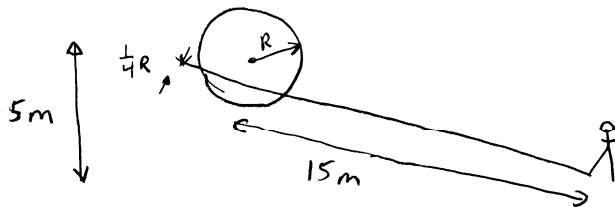
Question(s): What is the problem asking you to find?

What is speed at bottom and how long does boulder take to roll down the ramp.

Approach: Outline the approach you will use.

Use cons of energy with rolling motion to get final velocity

Use kinematic equations to get time.

DESCRIBE the PHYSICS
Draw physics diagram(s) and define ALL quantities uniquely.
(Mechanical energy is conserved, so draw a before and after situation for energy conservation as we did in class.)

$\langle Energy \rangle$

Before	Transfer	After
$y_1 = 5m$	None	$y_2 = 0$
$V_1 = 0$		$V_2 = ?$
$\omega_1 = 0$		$\omega_2 = V_2 / R'$

$$R' = (R - \tfrac{1}{4}R)$$

Motion diagram

$\bullet \ V_1 = 0$
$\ \ \ X_1 = 0$
$\ \ \ t_1 = 0$
$\ \ \ a = ?$

$\rightarrow +x$

$V_2 = ?$
$X_2 = 15m$
$t_2 = ?$

Which of your defined quantities is your Target variable(s)?

V_2 , t_2

Quantitative Relationships: Write equations you will use to solve this problem.

$$W_{ext} = \Delta K + \Delta U + \Delta E_{int}$$
$$K = \tfrac{1}{2}mv^2 + \tfrac{1}{2}I\omega^2 \qquad \omega = \frac{V_{cm}}{R}$$
$$U = mgh$$

$$\Delta x = \left(\frac{V_0 + V_1}{2}\right)\Delta t$$

PLAN the SOLUTION
Construct Specific Equations (Same Number as Unknowns)

$$W_{ext}^{\;\;0} = \Delta K + \Delta U + \Delta E_{int}^{\;\;0}$$

$$K_1 + U_1 = K_2 + U_2$$

$$0 + mgy_1 = \tfrac{1}{2}mv_2^2 + \tfrac{1}{2}I\omega_2^2$$

UNKNOWNS

$$\cancel{m}gy_1 = \tfrac{1}{2}\cancel{m}v_2^2 + \tfrac{1}{2}\left(\tfrac{2}{5}\cancel{m}R^2\right)\left(\tfrac{v_2}{R'}\right)^2$$

V_2

$$gy_1 = \tfrac{1}{2}v_2^2 + \tfrac{1}{5}v_2^2\frac{R^2}{\left(\tfrac{3}{4}\right)^2 R^2}$$

$$gy_1 = \tfrac{1}{2}v_2^2 + \tfrac{16}{45}v_2^2 = \tfrac{77}{90}v_2^2$$

$$\boxed{V_2 = \sqrt{\tfrac{90}{77}gy_1}} \qquad \textcircled{1}$$

$$X_2 - X_1^{\;\;0} = \left(\frac{v_1^{\;0} + v_2}{2}\right)(t_2 - t_1^{\;0})$$

$$\boxed{t_2 = \frac{2x_2}{v_2}} \qquad \textcircled{2}$$

Check Units

For ① $\left\{\dfrac{[L]}{[T]^2}[L]\right\}^{\frac{1}{2}} = \dfrac{[L]}{[T]}$ ok

For ② $\dfrac{[L]}{[L]/[T]} = [T]$ ok

EXECUTE the PLAN
Calculate Target Quantity(ies)

$$V_2 = \left\{\left(\tfrac{90}{77}\right)(9.8\,{}^m\!/_{s^2})(5.0m)\right\}^{\frac{1}{2}} = 7.6\ {}^m\!/_s$$

$$t_2 = \frac{2(15.0m)}{7.6\,{}^m\!/_s} = 4.0\ s$$

EVALUATE the ANSWER
Is Answer Properly Stated?

Yes, in ${}^m\!/_s$ and time

Is Answer Unreasonable?

No, speed and time are reasonable

Is Answer Complete?

Yes

(extra space if needed)

Write your Group Number here and the names of the group members who are present.

Group Number:_____

Name:____Key_____

Name:_____

Name:_____

Name:_____